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MONTEREY, CALIFORNIA

Unmanned Vehicle Distributed Sensor Management and Information Exchange Demonstration

by

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On 24 Feb 2004 the Naval Postgraduate School, Commander, THIRD Fleet staff, and AKSI Solutions, LLC, conducted a demonstration for information exchange from a local network of distributed sensors, to a remote decision-making node. The goal was to establish connectivity between the two nodes, assess quality of relayed data transmission from distributed sensors, and determine viability of the technology for future testing and evaluation of distributed sensor information exchange for maritime missions. The demonstration brought to light the impact of limited bandwidth for data flow, dependence of information quality on collection management, and the need for an architecture to support the recognized maritime picture information exchange. This paper describes the demonstration, expectations, outcomes, and implications for follow-on testing, sensor management applications, information exchange, and use of prototype systems that support emerging technologies.

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ABSTRACT

On 24 Feb 2004 the Naval Postgraduate School, Commander, THIRD Fleet staff, and AKSI Solutions, LLC, conducted a demonstration for information exchange from a local network of distributed sensors, to a remote decision-making node. The goal was to establish connectivity between the two nodes, assess quality of relayed data transmission from distributed sensors, and determine viability of the technology for future testing and evaluation of distributed sensor information exchange for maritime missions. The demonstration brought to light the impact of limited bandwidth for data flow, dependence of information quality on collection management, and the need for an architecture to support the recognized maritime picture information exchange. This paper describes the demonstration, expectations, outcomes, and implications for follow-on testing, sensor management applications, information exchange, and use of prototype systems that support emerging technologies.

EXECUTIVE SUMMARY

On 24 Feb 2004, the Naval Postgraduate School (NPS), Commander, THIRD Fleet, (C3F) staff, and AKSI Solutions, LLC, conducted a demonstration for information exchange from a local network of distributed sensors to a remote decision-making node. The purpose of the demonstration was to characterize an operational information architecture for data flow from tactically employed, distributed aerial and ground sensors to a remote decision-making node. The objectives of this demonstration were to:

1. Determine connectivity between the two nodes.
2. Assess quality of relayed data transmission from distributed sensors.
3. Determine viability for future testing and evaluation of distributed sensor information exchange for maritime missions.

This test met these objectives, identified by C3F and NPS, and yielded insight into collection management issues and bandwidth limitations for naval combatants.

The C3F remote node received data at 26 Kbps and experienced no outages during the demonstration. Network operations supported the flow of available data forwarded from distributed sensors to a local host. Sensor data was accessible only at the local tactical network, precluding relay to the remote decision-making node, however. The local network interfaced near real time (six second refresh rate) with a centralized XML database that supported 18 participants, 14 of which were sensor platforms, two communications relays, the local host, and the remote node. The interface used a software application developed by AKSI.

While expectations and objectives distinguished data flow, information quality, and scalability issues, the demonstration brought to light the impact of limited bandwidth for data flow, dependence of information quality on collection management, and the need for an information architecture to support the recognized maritime picture (RMP).

Key conclusions and recommendations are to

- continue with follow-on testing;
- improve current sensor management applications by incorporating an operator interface, to include contact information on the same display;
- incorporate tactical-level decision makers in follow-on testing;
- specify the structure for information exchange; and,
- experiment using the prototype systems that support emerging technologies.

SECTION 1: INTRODUCTION

1.1. SUMMARY

On 24 Feb 2004, the Naval Postgraduate School (NPS), Commander, THIRD Fleet, (C3F) staff, and AKSI Solutions, Inc., conducted a demonstration for information exchange from a local network of distributed sensors to a remote decision-making node. The local host was a test site in Camp Roberts, CA, where NPS-affiliated operators and technicians were to deploy and operate unmanned aerial vehicles, and also unattended and human-portable ground sensors. The remote node was a space within the C3F shore headquarters. The purpose of the demonstration was to characterize an operational information architecture for data flow from tactically employed distributed aerial and ground sensors to a remote decision-making node. The objectives of this demonstration were to:

1. Determine connectivity between the two nodes.
2. Assess quality of relayed data transmission from distributed sensors.
3. Determine viability for future testing and evaluation of distributed sensor information exchange for maritime missions.

1.2. OPERATION DESCRIPTION

The communication system was divided into two distinct sections. The first was an 802.11-based local network with high data rate capability for interaction among multiple air assets and ground sensors. Addition of a mobile access router to support the data flow via Link 16, or Link 11, can provide higher bandwidth in the future. An initiative to use 802.16 can provide increased bandwidth in the feed from the sensors. However, in an effort to meet objectives expeditiously, the local network used 802.11b wireless protocol.

The second part of the system used an Internet connection to feed data to an over-the-horizon (OTH) command node. Although desired to send sensor data to the

remote site, the system only integrated these two nodes by enabling data flow of distributed sensor status between them. The interface with this system was a software application developed by AKSI. It provided collection management information to decision makers to evaluate and manage but yielded no operational or tactical level reports of contacts. Regarding this remote link, the Internet is not the desired or planned final link; it also presented itself as the most feasible initial connection with IMARSAT, Iridium, or portable satellite radio as other options.

This demonstration will assist in developing tactics, techniques, and procedures for incorporating unmanned vehicles and distributed sensors for building and maintaining a recognized maritime picture (RMP). The term, RMP, is used interchangeably with common operational picture (COP).

1.3. OPERATIONAL ADEQUACY

This test met the objectives identified by C3F and NPS and yielded insight into collection management issues and bandwidth limitations for naval combatants. However, the initial premise of the operation regarded carrier strike group (CSG) stated needs to maintain a continuous RMP of the vital area. Unmanned vehicles (UVs) and unattended sensors pose a means to cover this capability gap. Capitalizing on their data requires access to a tactical network that will improve combat effectiveness and enhance operational understanding. The demonstration attempted to extend this to operational-level observers.

The network established a regularly updated distributed sensor grid status via an Internet connection rated at less than 33 Kbps. These data rates are insufficiently high to meet the demands of remote operational-level decision makers for sensor video or image data. **The most significant finding of this demonstration is that an adequate amount of sensor data and status does reside at the local (tactical level) network, and that collection management processes and information exchange between tactical and operational levels require further research.**

1.4. TEST LIMITATIONS

The test area and sensor assets limited the demonstration to overland operations. Regardless, this still enabled evaluation of the sensor grid disposition. Weather and technical delays caused scheduling perturbations and precluded inclusion of UAVs in the collection management display. Subsequent testing allowed integration of these assets in the Internet accessible display. There were no simulated target vehicles for tracking.

SECTION 2. EXPECTATIONS

2.1. OPERATIONAL EFFECTIVENESS

Previous trials, conducted by NPS in 2003, featured UAV sensor data with limited understanding of platform location and disposition. The U.S. Navy is contemplating deployment of numerous distributed sensors in support of tactical and operational units. This requires integration of multiple sensors for enhanced knowledge management, as well as improved command and control for operational and tactical commanders. The primary effectiveness issue remains: **Can data flow between the local distributed sensor network and the remote decision-making node?**

Successful data transfer is the baseline for information exchange. Success implies that the local network passes sufficient data conveying complete, timely, and accurate information to the remote decision-making node. The expectation was for exchange of detection, location, classification, and identification information. However, the demonstrated operability focused on updating sensor node status. Despite the difference between expectation and observation, the demonstration provided satisfactory insight into distributed sensor operations, enabling consideration of two other critical operational issues. **Does the remote connection provide satisfactory quality information?** And, **should the test be expanded to forward multiple sensors' data to a ship's combat information center or Sea-based Battle Lab?**

2.2. DATA FLOW

The graphical representation of the demonstration in Figure 1 shows the flow of data collected by the local network's remote sensors and distributed to the local host node via network connections. The contacts of interest are expected to appear during network updates. While an optimal refresh rate is unknown, for the system to be tactically useful, the RMP should reflect near real time activity. This model assumes that as sensor operators and analysts update the database, the decision-making node receives the

updates remotely, through the database, and the system status, with all contacts included, is displayed on the user interface. From this view, the decision-making node can make adjustments based on available information and provide feedback to the local host.

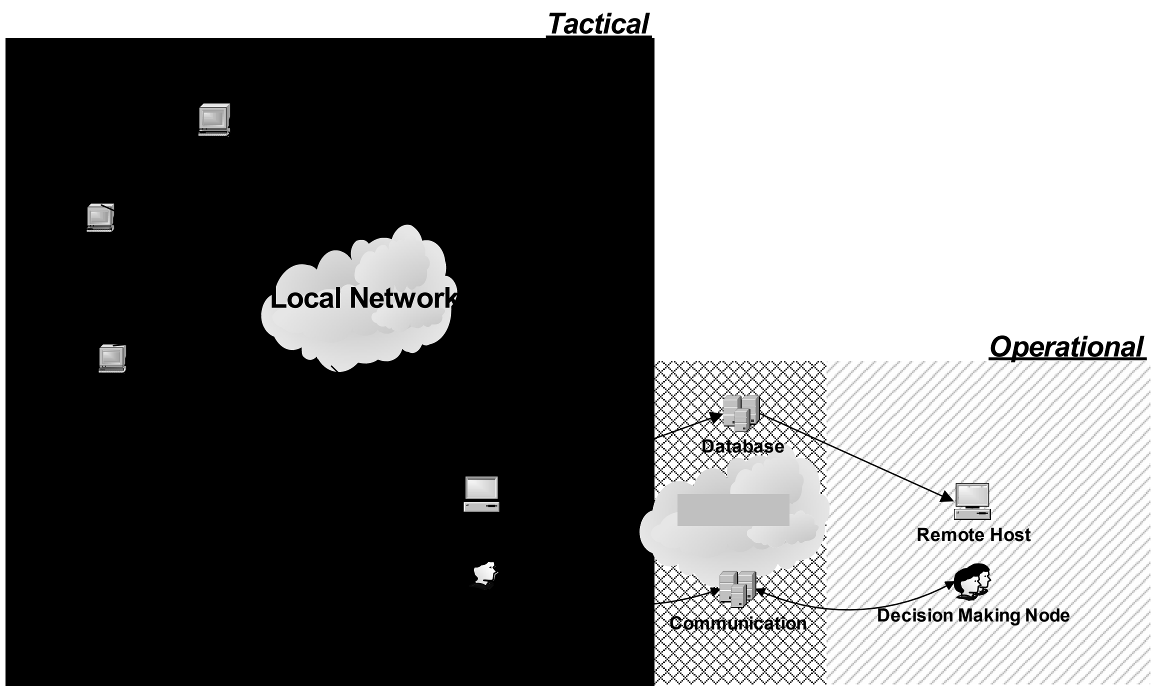


Figure 1. Link between local network and remote decision making node.

2.3. INFORMATION QUALITY

Studies regarding the quality of information assess its timeliness, accuracy, and completeness [Perry, 2002]. While the network model is suitable for data flow, a layered model is more appropriate for information quality, as depicted in Figure 2. As time progresses, data refinement provides information which can then provide tactical insight and operational understanding. Analogously, there are several layers of contact information resident within the RMP database. Beyond the simple kinematics or identification elements, there is access to essential elements of information (EEI) and answers to operational commander’s priority intelligence requirements (PIR).

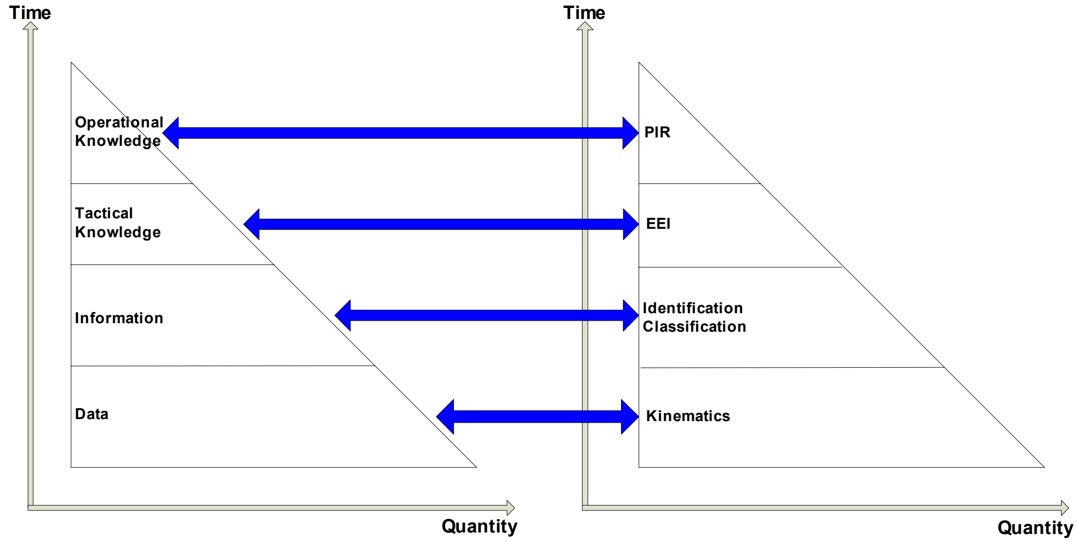


Figure 2. Levels of information quality [based on Nissen, 2002].

Sensors accumulate data on contacts, and operators ensure transformation of the data into information for use by decision makers. Decision makers apply operational understanding to inform their basis of knowledge regarding the RMP. The relationship between the local host of a distributed sensor network and the decision-making node suggest an open systems architecture, in which the final recipient of the information must provide feedback to the initial sender. This is done to clarify information that is obscure or to reassess the RMP. Although the remote sensor data are initially the responsibility of the sender of information, this responsibility shifts to the decision-making node as the principal stakeholder when operational requirements for essential elements of information emerge. Likewise, the collection management burden shifts from local to remote. Control of UVs over the network can potentially reduce the number of operators and increase collaborative behavior as well.

Ideally, the right sensors are in the right place, at the right time. This is a dynamic situation in which decision makers remain apprised of the emerging operational picture and compare it to the status of collection assets. It is therefore critical to establish the proper flow of information from sender to receiver in order to align the distributed sensor grid to a changing scenario. Absent "intelligent" sensors that alert operators to specified

activity of interest, dynamically matching distributed sensor performance to emerging events requires management and observation of tactically significant events. This speaks to a requirement for a collection management tool, which displays available networked sensor disposition, updates frequently, and enhances operational understanding.

2.4. PROSPECTS FOR EXPANSION

A greater number of sensors increases the amount of data flowing and do not necessarily lead to improved decision making. Regardless of sensor grid size, the expectation is for a responsive network that provides timely, critical, relevant information in the appropriate quantity, to the decision maker. Deviation can lead to information overload and an incorrect understanding of the current situation. Specifying appropriate routing of distributed sensor information applying to both operational and tactical levels of interest provides structure for management. Future testing can explore criteria for evaluating distribution of information from networked sensors, which can yield insight into collection management. Such testing will require an information architecture, defining reporting responsibilities; establishing decision rights for sensor tasking; and enabling dynamic realignment of sensors to support operational objectives.

SECTION 3: OBSERVATIONS

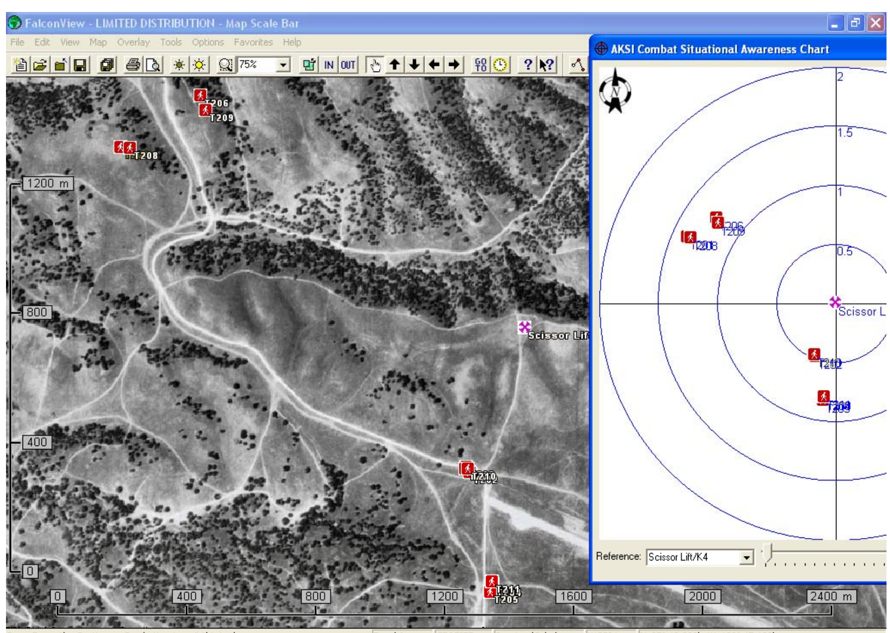
The local NPS host site at Camp Roberts received network participant status information, and also data from unmanned-vehicle and human-portable sensors. The remote C3F decision-making node also received the sensor distribution and status—but not the data feed—via an application developed by AKSI that accessed an XML database using a 33Kbps Internet connection. This demonstration provided insight into collection management issues, but limited observation of sensor information exchange. The Test Plan [Appendix A] cited critical operational issues for interoperability, compatibility, capability, and reliability.

3.1 DATA FLOW (INTEROPERABILITY)

The remote node received data at 26 Kbps and experienced no outages during the demonstration. As observed at the site, this emulates bandwidth restrictions confronting naval combatants, which typically deploy with limited bandwidth access. Data included the same geographic presentation of sensor disposition as at the local host.

3.2. INFORMATION QUALITY (COMPATIBILITY)

In front of a decision table at the host node, two large projections showed a geographically based distribution of all networked sensors, Figure 3, and selected split-screen digital sensor feeds from



multiple platforms. This enabled local site personnel to equate sensor data and location. This is not a report on the capabilities of sensor types available for developing a common operational picture. There were, for example, no networked sensors able to fix the position of a contact. Regardless, network operations supported flow of all available data forwarded from distributed sensors to the local host.

Sensor data was accessible only through the local tactical network, precluding relay to the remote decision-making node. In fact, the focus of associated testing is the capability of local operators to manage and process distributed, networked assets. C3F was able to access sensor status and monitor collection asset disposition, however. This limitation prevented assessment of critical technical parameters such as video transmission rates, high-resolution, loss-less image transfer, or total data rates. To address the operational decision-maker requirements requires adaptation of the architecture used in a local network to provide higher-level information exchange and understanding.

3.3. EXPANSION PROSPECTS (CAPABILITY)

Collection management personnel accessed position, status (online or offline) and time of last update for any sensor and participant in the network. The local network refreshed a centralized XML database at a six second update rate. This enabled satisfactory knowledge of sensor disposition, but, due to weather and extraneous technical issues, no air platforms were in the network at the time of the demonstration. All told, the database supported 18 network participants, 14 of which were sensor platforms, two communications relays, the local host, and the remote node.

3.4. OTHER CRITICAL ISSUES

Regarding secondary objectives, the demonstration provided an opportunity to assess other capability, compatibility, and reliability issues, as outlined in the Test Plan. Using a text-based chat session, two-way communications existed for potential dynamic tasking of distributed sensors from a remote node. This link provided an integrated feedback line

from which decision makers communicated on demand with local host personnel, reinforcing an open-systems approach toward collection management. While set-up and link acquisition at the local level was not observed, incorporating the remote node was straightforward and practical.

A significant compatibility issue is whether this distributed sensor interface supports standard Navy architecture to feed the RMP. Incorporation of Link 16 or Link 11 compatibility with mobile access routers would establish this connectivity. However, neither observers, or analysts, or participants are aware of any tactical level unmanned vehicle sensor that directly feeds a common picture through any program-of-record interface. Further discussion of this compatibility issue is in the next section. Finally, the system experienced no failures during the demonstration.

SECTION 4: DISCUSSION AND ANALYSIS

While expectations and objectives distinguished data flow, information quality, and scalability issues, the demonstration brought to light much interaction among these concepts with implications for actual operations. Insights can guide development of doctrine and shape future testing. In particular, the February demonstration provided insight into the impact of limited bandwidth for data flow, dependence of information quality on collection management, and characterization of the RMP.

4.1. BANDWIDTH LIMITATIONS

As discussed, bandwidth limitations on U.S. Navy combatants restrict the amount and type of data flowing through a network. Transmitting video data from distributed platforms requires megabytes of bandwidth, not kilobytes, and as C3F node personnel noted, "it's what everyone wants to see [AKSI, 2004]." This requires fuller analysis. In essence, data flow supports essential information requirements to establish the RMP, and priority requirements per operational commander intentions. The RMP nominally resembles a database, where contacts equate to records whose fields conform to kinematics, identification, and intelligence data. The importance of a contact's information is highest as one climbs the hierarchy.

At the top of the hierarchy are the most demanding data fields: those that support priority intelligence requirements. If the operational levels merely require answers to these questions, then a text rendering of the answers is sufficient; however, if corroborating or analysis tools reside only at that high a level, then image or video data will have to flow from the local network to a remote node. Defining where data fusion and analysis occurs is an architecture decision. When assigning tactical distributed sensors to gather potentially essential elements of information, the technical and operational architecture must delineate where data interpretation occurs, because this, in part, drives bandwidth allocation.

4.2. COLLECTION MANAGEMENT AND INFORMATION QUALITY

Although collection management was not an original objective of this demonstration, it became evident that (1) this was the data being relayed to the remote node, and (2) it is a key to proper employment of distributed sensor platforms. Information quantity, timeliness, and accuracy are predicated on proper sensor grid disposition. Subsequent sensor employment is revised based on prior preparation, current results, and emergent conditions [Washburn, 1996]. If an unmanned sensor holds no useful data in its field of regard, operators will simply redirect the asset elsewhere. By augmenting an operator's perspective on multiple sensor data with the geographic display, an individual can manage a number of platforms concurrently and refocus grid efforts as desired.

The local host capability to synthesize sensor data with grid disposition enables operators at that node to redistribute assets as required. Absent sensor data, the remote decision making node holds no such understanding. A single picture summarizing geographic disposition of sensors and contacts may enable collection management from wherever this display resides, locally or remotely. This entails either a Navy RMP display program of record incorporating UV sensor data or an experimental integration of common tactical information—as shown in Figure 3—into the sensor display. The need for consolidating information into a single display becomes more critical as the number of sensors increases.

There are particular implications here for the current template of multiple operators per unmanned moving sensor. At a minimum, there is one operator per platform and often two—one to pilot and the other to operate payload. Data flows from sensor platform via direct data link to a stand-alone display. Adaptive networking of these displays is a technological initiative of the NPS studies, but these still cannot feed into fielded systems that present the common operational picture. Stovepipes for data flow combine with a need to inform the RMP, suggesting another architectural decision regarding the appropriate level of data entry: where UV data enters the common picture.

4.3. RMP CHARACTERIZATION

This demonstration yielded several different perspectives on the recognized maritime picture. It is a database that forms the common picture; a server that supports numerous nodes; a presentation that aids decisions; and, a tool for managing information collection. The open systems architecture receives inputs from operators and analysts who process data from distributed sensors, and presents information to decision makers, such as composite warfare commanders. Their actions affect the environment in which these sensors operate, requiring reassessment and potential reorientation of sensor efforts. To the extent that these developments support operational objectives, collection managers at that level assess the degree of meeting commander's intent. This means that there are five layers of RMP management: the distributed sensors, operators and analysts, local platform hosts, tactical (warfare) decision makers, and operational command. The multilayer implications on the success or failure of the RMP make clear the requirement to define responsibilities for collection management throughout this organization.

SECTION 5: CONCLUSIONS

This demonstration helped frame several issues regarding employment, management, and integration of unmanned vehicles and distributed sensors. **Future testing is required to develop an organizational and procedural structure to support this.** The current analysis does suggest some specific action, experiment design, and technical direction to enable evaluation. These include the need to integrate sensor and contact information in a single display, to include tactical decision makers, to address technological compatibility issues, and to specify an information exchange architecture for this multilayered, distributed sensor network.

- **Single display for networked nodes and contacts.** This type of presentation will enable appraisal of the alignment between unmanned vehicle and sensor employment with operational developments. An XML database structure can support this, with automated updates for networked assets. Contact information will rely on operator input, absent any auto-tracking sensor platforms.
- **Inclusion of tactical decision makers.** The functions of RMP management and asset allocation reside at the tactical level. Activity at this level will permit higher resolution analysis of the processes and structure required for maintaining an RMP using unmanned vehicles.
- **Model for information exchange.** Definition of layered information exchange will result in an operational architecture for implementation in follow-on tests. These guidelines, procedures, and organization should be the focus of experimentation. Resulting insight will contribute to developing Navy doctrine for incorporating unmanned vehicles into Fleet operations.
- **Technological incompatibilities.** Tactical UV and remote sensor data relays are stovepipes. These technologies and the potential software integration are emerging and make Navy standard configuration management—for integration into GCCS-M, as an example—an unlikely prospect for resolution before follow-on testing. Testing should focus on developing the qualities

desired in UV and distributed sensor integration and encouraging the Navy engineering community to incorporate these elements in future RMP versions.

In summary, the key conclusions are to improve current sensor management by incorporating an operator interface to include contact information on the same display; include tactical-level decision makers in follow-on testing; specify the structure for information exchange; and to experiment using the prototype systems that support emerging technologies.

APPENDIX A

Unmanned Vehicle Distributed Sensor Management and Information Exchange Demonstration 24 February Demonstration: Test Plan Commander, THIRD Fleet & The Naval Postgraduate School

SECTION 1: INTRODUCTION TO THE PROJECT

1.1 PURPOSE

To characterize the operational view of communications architecture for flow of data from tactically employed distributed aerial and ground sensors to a decision-making node.

1.2 SYSTEM DESCRIPTION

The communication system is divided into two distinct sections. The first is an 802.11-based local network with high data rate capability for interaction among multiple air assets and ground sensors. The second part of the system utilizes an Internet connection to feed video/text/data transfer with an over the horizon (OTH) command node. The system integrates these two elements and enables data flow between them, providing operational information to decision-makers to evaluate and manage.

SECTION 2: MISSION NEED AND OPERATIONAL REQUIREMENT

2.1 MISSION NEED

A forward deployed carrier strike group (CSG) staff has identified a lack of assets to maintain a continuous recognized maritime picture (RMP) of the vital area. Unmanned vehicles (UVs) and unattended sensors pose a means to cover this capability gap. Capitalizing on their data requires access to a tactical network that will improve combat effectiveness and enhance operational understanding. This network must have an interface allowing for open systems architecture, with data rates sufficiently high to meet the demands of remote decision makers. These requirements include integration of multiple sensors for enhanced knowledge management, as well as improved command and control for operational and tactical commanders. The system must provide a means of relaying real-time or near-real-time essential elements of information to OTH assets.

SECTION 3: SCOPE OF THE EVALUATION

3.1. CRITICAL TECHNICAL PARAMETERS

3.1.1 Maximum time to initiate link (seconds)

3.1.2 Video transmission rate (frames/sec)

3.1.3 Still image transfer rate (lossless compression) (mega pixel/sec)

3.1.4 Maximum number of link interruptions per hour

3.1.5 Total data rate

3.2 CRITICAL OPERATIONAL ISSUES

COI 1. **Can data flow between the local distributed sensor network and the remote decision making node?** (Interoperability)
COI 2. **Does the remote connection provide satisfactory quality information?** (Capability)
COI 3. **Should the test be expanded to forward multiple sensors' data to a ship's combat information center or the Sea-based Battle Lab?** (Compatibility)
COI 4. Is there sufficient two-way communication to dynamically task distributed sensors from remote decision making node? (Capability)
COI 5. Is the set up and link acquisition time short enough for practical use? (Capability)
COI 6. Can the distributed sensor interface support standard Navy architecture to feed recognized maritime picture? (Compatibility)
COI 7. Does the system have a low failure rate? (Reliability)

3.3 NAVY MISSION ESSENTIAL TASK LIST (NMETL) AND CANDIDATE METRICS

During this demonstration, observers will assess the potential of measuring the following NMETL metrics at the remote node in future tests and experiments.

- Collect data and intelligence (2.2)
  - Percent of PIRs have at least one source that yielded intelligence information (M3)
  - Hours after PIR satisfied, collection asset is retasked (M4)
  - Percent of PIRs have more than one source that yielded intelligence information (M6)
  - Hours since most current intelligence information collected (M7)
  - Number of images exploited (M9)
  - Time to exploit images received (M10)
- Disseminate and integrate intelligence (2.5)
  - Hours to pass prepared intelligence to the force (M2)
  - Minutes to disseminate updates upon receipt of new intelligence (M3)
  - Minutes after observation of activity, a report is disseminated (M4)
  - Hours to disseminate intelligence updates upon completion of assessment (M5)
  - Time to post image to home page or transmit via SIPRNET (M6)
- Process targets (3.1)
  - Percent of selected targets have accurate coordinates available (M2)
  - Time to identify target as High Priority Target (HPT) (M4)
  - Incidents of Blue-on-Blue engagement (M13)
  - Incidents of Blue-on-White engagements (M14)
- Acquire, process, and communicate information (5.1)
  - Hours since latest information collected (M5)

- Percent of available information examined and considered in latest status report (M6)

- Analyze and assess situation (5.2)
  - Minutes to complete assessment of latest information (cycle time) (M1)
  - Percent of available reports reviewed (M2)
  - Hours since last update of Force situation (M7)

3.4 GENERAL TEST OPERATIONS, TEST VEHICLES AND TEST OVERVIEW

Set-up and testing will take place at the CIRPAS facility located at Camp Roberts, CA and Commander, THIRD Fleet, Shore Headquarters in San Diego, CA. The local distributed sensor network, called the Surveillance and Targeting Acquisition Network (STAN), will have been operating several days prior to this demonstration at Camp Roberts. The site will have two NPS observers recording information gathering, processing, and dissemination. A technician will arrive at THIRD Fleet on the morning of 24 February to set up the remote decision-making node using a dial-up Internet connection (33Kbps). An ONR S&T Unit 113 observer will record remote site activity and feedback from two C3F observers.

3.4.1 DEMONSTRATION

The first element of the demonstration is a check of basic functionality of the information exchange between STAN and the remote site. All portions of this test will be conducted on the ground. The level of interoperability will also be examined.

3.4.2 GOALS FOR DEMO

1. Determine connectivity between the two nodes.
2. Assess quality of relayed data transmission from distributed sensors.
3. Determine viability for future testing and evaluation of distributed sensor information exchange for maritime missions.

3.4.3 DEMONSTRATION TEST EVENTS

For the purpose of synchronizing activities, the following events outline the expected course of events. Observers will capture narrative explaining deviations between observation and expectation. Observers will coordinate via phone line and text-based chat to ascertain status of demonstration.

1. Determine connectivity. Assess connection between remote unmanned sensors (Camp Roberts), STAN (Camp Roberts), AKSI Tracker (Transmitter Node/Camp Roberts), and AKSI Tracker (Receiver Node/San Diego).
2. Inventory sensors. Observers at Camp Roberts will identify participating sensors within the local network and report to C3F (Decision Node/ San Diego) via voice communications.
3. Update database. Payload Operators pass information to STAN and AKSI

Tracker (Transmitter Node) ensures inclusion of sensor and contact information, and verifies updates information database (substitute for RMP). Activities associated with steps four through six will require updates to RMP substitute database.

4. Detect contacts. Available STAN sensors will gather data for collection at the local AKSI Tracker. Observers assess sensors and current sensor data. Deployed sensors detect unknown contact. Remote sensors update recognized picture (substitute for RMP) accordingly. **Criteria** for basic levels of detection information should include the following kinematics:

   - Position
   - Course/Heading
   - Speed
   - Receive visual cues/light
   - Receive audible cues (if available)

5. Classify and identify contacts. STAN Network operators will assess available sensors and evaluate whether data enables classification and identification. AKSI Tracker (Transmitter Node) verifies inclusion in picture shared with C3F. **Criteria** include:

   a. Classification:
      - General Type: Commercial/Civilian/Combatant
        - Friendly/Unknown/Potentially Hostile

   b. Identification
        - Determine point of origin
        - Single or Multiple Contacts
      - Identification Number (if available)
      - Threat priority

6. Manage critical information. Payload operators will determine whether sensors captured any priority intelligence requirement/essential element of information (PIR/EEI). **Criteria** relevant to a PIR/EEI contact of information (COI) include:

   - Number and characteristics of personnel associated with COI
   - COI cargo and physical characteristics
   - Suspicious or unusual activity
   - Movement of COI and possible avenues of approach
   - Maneuvers to evade surveillance
   - Condition of readiness and defensive nature of target
   - Number, location, and types of weapons carried onboard including topside or portable weapons
   - Unusual obstructions or any evidence of preparations to impede surveillance operation

7. Assess information exchange. C3F Decision Node receives updated information from steps four through six via AKSI Tracker (Receiver Node) and confirms receipt of information. C3F Decision Node evaluates information for completeness, based on above criteria.
8. Refine information quality. AKSI transmitter and receiver nodes refine information flow based on assessment of inadequacies in capturing detection, classification, identification, and critical information. Update STAN networked sensor fields of regard as possible. Maneuver UV as necessary to resolve ambiguities.
9. End of demonstration. Once satisfied, C3F Decision Node will end demonstration. Conduct hot wash-up of observations. Develop appropriate course of action.

3.4.4 Instrumentation

All transmitted data will be archived at a remote server. Observers will compile narrative logs throughout demonstration.

3.4.5 Limitations to Scope of Test

Safety of operations will drive achievement of objectives at Camp Roberts. Loss of any aircraft, manned or unmanned, or any technical equipment in the course of conducting this demonstration is not worth the insights expected. All sensor employment is subject to the judgment of the Principal Investigator, Dr. Netzer.

3.4.6 Environment

Ground tests may be conducted at any time and in any conditions with the exception of a baseline trial for establishing range and performance data.

3.4.7 Assets

With the exception of C3F staff participation, all aircraft, sensors, technical support, and system components are considered organic to the Naval Postgraduate School unmanned vehicle experimentation series.

3.4.7.1 Aircraft

Aircraft include one manned tactical UAV surrogate (Cessna 404, with EO and IR sensors and mobile network router), one TERN UAV (operated by VC-6, with EO and IR sensors), one SWIFT UAV (operated by SOCOM, with EO sensor), and one aerostat (with mobile network router).

3.4.7.2 Sensors

Sensors include unattended electro-optic, video and IR cameras; passive IR, broadband

and narrowband acoustic, seismic, and microwave sensors; and, magnetic detectors.

3.5 COORDINATION

Desired coordination will be via text chat through the network interface. The Camp Roberts site phone number is (714) 225-7198. The C3F site can be reached at (619) 368-0509.

3.6 REPORT

The Naval Postgraduate School with assistance from ONR S&T Unit 113 will generate a report on demonstration results and prospects for further testing no later than 20 March 2004.

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